Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a Microcontroller
Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748

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Integrated Circuit Card

10

16

Card Java Virtual Machine
(Card JVM)

12a Communicator

14

12b Terminal
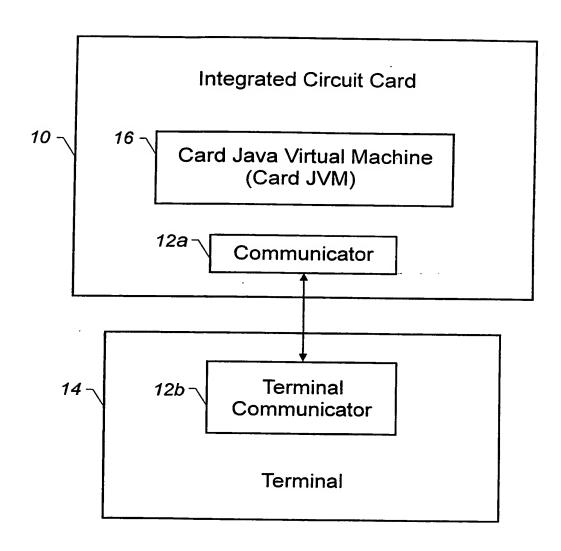Communicator

Terminal

FIGURE 1

FIGURE 2

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Serial No. 10/037,390
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Application
Class Files ⟋ 24

COMPILED
CODE FOR
CLASS A
(A.CLASS)

24b

COMPILED
CODE FOR
CLASS B
(B.CLASS)

24a

COMPILED
CODE FOR
CLASS C
(C.CLASS)

24c

String To ID
Input
Map

30

26

Card
Class File
Converter

27

Card
Class File
(contains
Classes
A, B, and C)

32

String To ID
Output
Map

FIGURE 3

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a Microcontroller
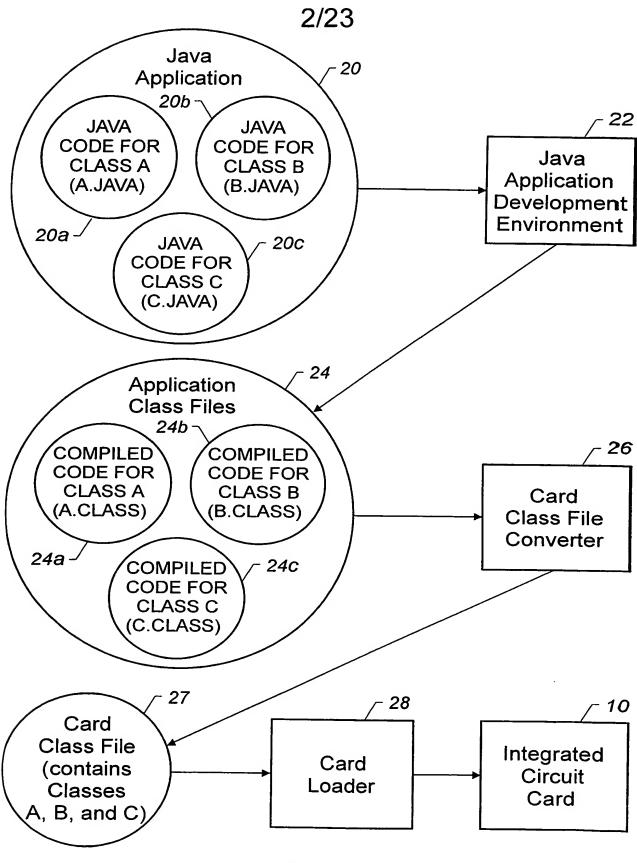Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748

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Application Class Files ⌐ 24

Class File Information

41 — Class File Information → Card Class File ⌐ 27

Card Class File Information ⌐ 46

42 — Class Constant Pool - Contains all the strings corresponding to Fields methods and Class names referred to in the Java program → Optimized Card Class Constant Pool where each string is replaced by an ID ⌐ 47

43 — Class, field, Interface and Method Information → Card Class, Card Field, Card Interface and Card Method Information ⌐ 48

44 — Attribute Information

←Source File Attribute

←Constant Value Attribute

Code Attribute —

←Exceptions Attribute

←Line Number Table Attribute

←Local Variable Table Attribute

←Optional Vendor Attributes

Card Attribute Information ⌐ 49

Code Attribute (optionally translated)

⌐ 24b,c

⌐ 45

Eliminated

⌐ 24a

FIGURE 4

Applicant: Wilkinson et al.
e: Using a High Level Programming Language with a M   troller
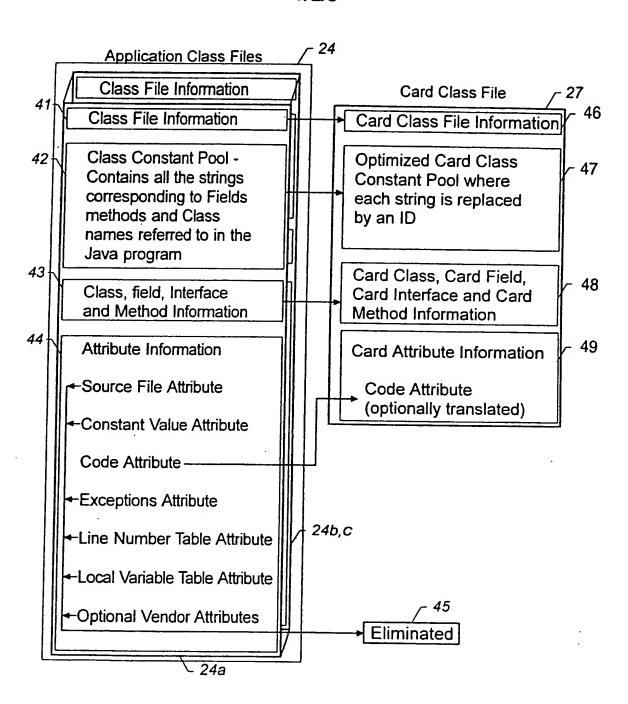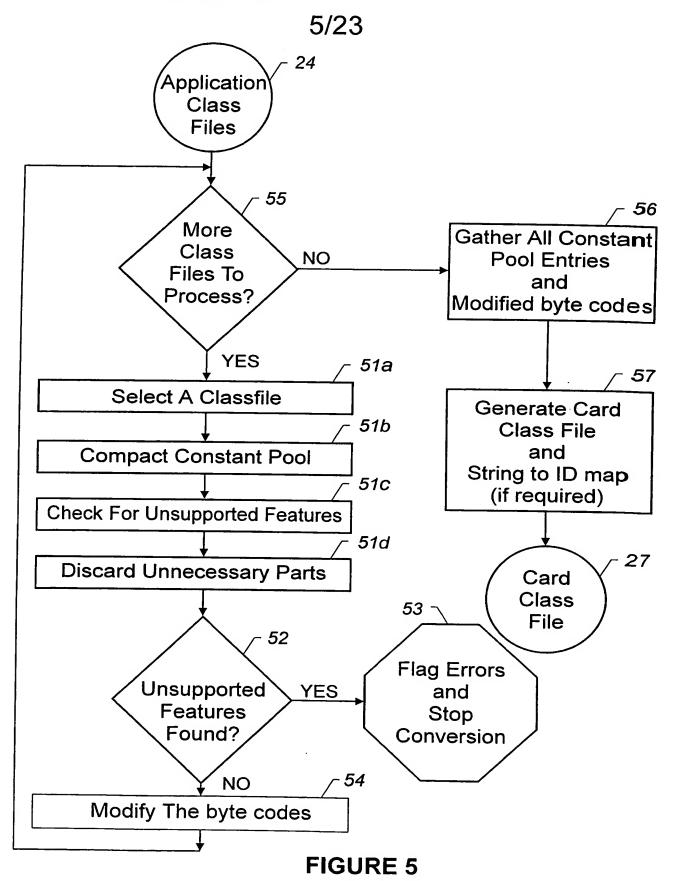erial No. 10/037,390
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Application Class Files — 24

More Class Files To Process? — 55

NO →

Gather All Constant Pool Entries and Modified byte codes — 56

YES

Select A Classfile — 51a

Compact Constant Pool — 51b

Check For Unsupported Features — 51c

Discard Unnecessary Parts — 51d

Generate Card Class File and String to ID map (if required) — 57

Card Class File — 27

Unsupported Features Found? — 52

YES →

Flag Errors and Stop Conversion — 53

NO

Modify The byte codes — 54

FIGURE 5

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a   Controller
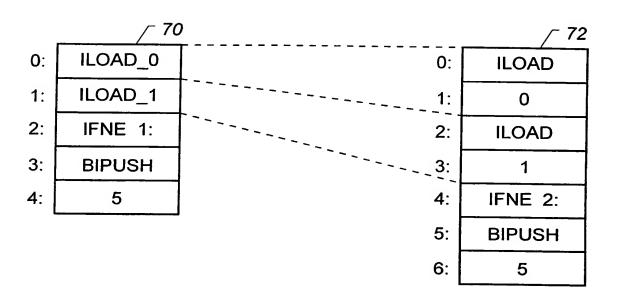Serial No. 10/037,390
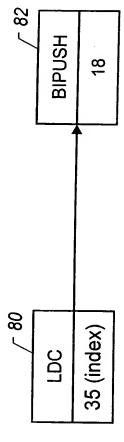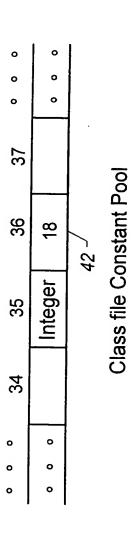Contact: Pehr B. Jansson, 512-331-3748

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Original byte codes
60

61

PASS 1: List all jumps and their destinations

62

NO ← Translate specific byte codes?

YES

63

PASS 2: Convert specific byte codes into generic byte codes

64

PASS 3: Relink References

65

NO ← Modify byte codes?

YES

66

PASS 4: Modify Java byte codes to Card JVM byte codes

67

PASS 5: Readjust Jumps

68

Modified byte codes

FIGURE 6

```
        ┌─ 70                                    ┌─ 72
0: │   ILOAD_0   │                     0: │   ILOAD   │
1: │   ILOAD_1   │                     1: │     0     │
2: │   IFNE  1:  │                     2: │   ILOAD   │
3: │   BIPUSH    │                     3: │     1     │
4: │      5      │                     4: │  IFNE  2: │
                                       5: │   BIPUSH  │
                                       6: │     5     │
```

FIGURE 7

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a ▇▇▇ontroller
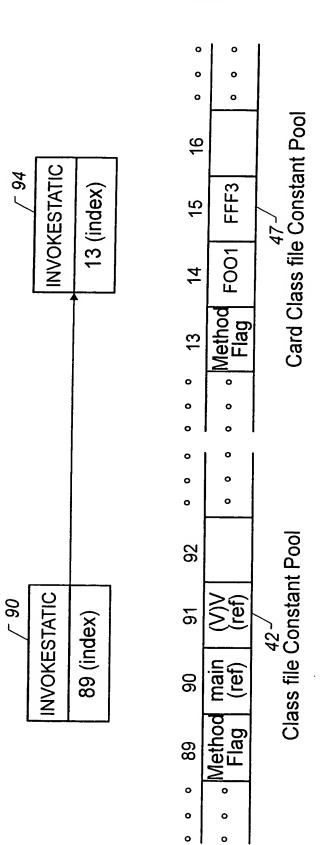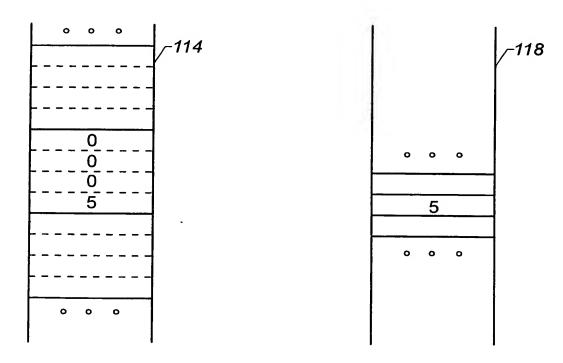Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748

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FIGURE 8

INVOKESTATIC — 94

INVOKESTATIC
13 (index)

INVOKESTATIC — 90

INVOKESTATIC
89 (index)

89	90	91	92	o	o	o
Method Flag	main (ref)	(V)V (ref)				

42 — Class file Constant Pool

13	14	15	16	o	o	o
Method Flag	FOO1	FFF3				

47 — Card Class file Constant Pool

FIGURE 9

	100
0:	ALOAD 43
1:	0
2:	ILOAD 21
3:	1
4:	IFNE 154 2:
5:	BIPUSH 16
6:	5

	102
0:	ALOAD 51
1:	0
2:	ILOAD 50
3:	1
4:	IFNE 27 2:
5:	BIPUSH 49
6:	5

FIGURE 10

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a Microcontroller
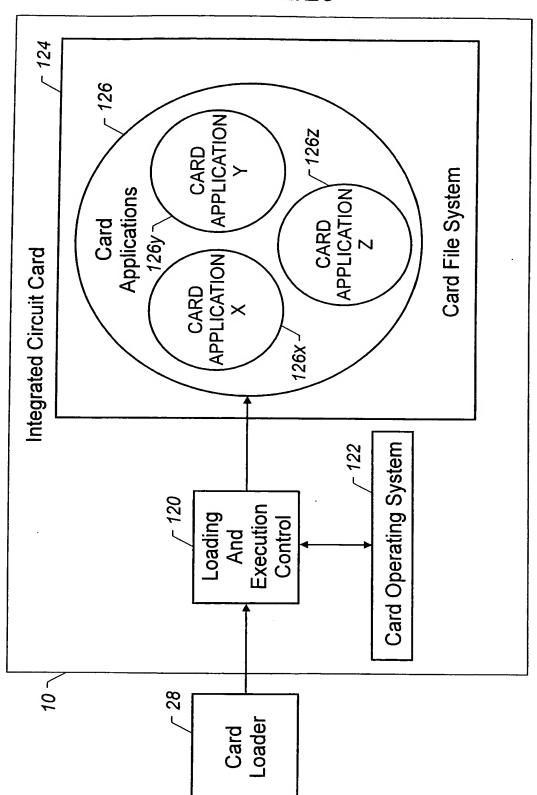Serial No. 10/037,390
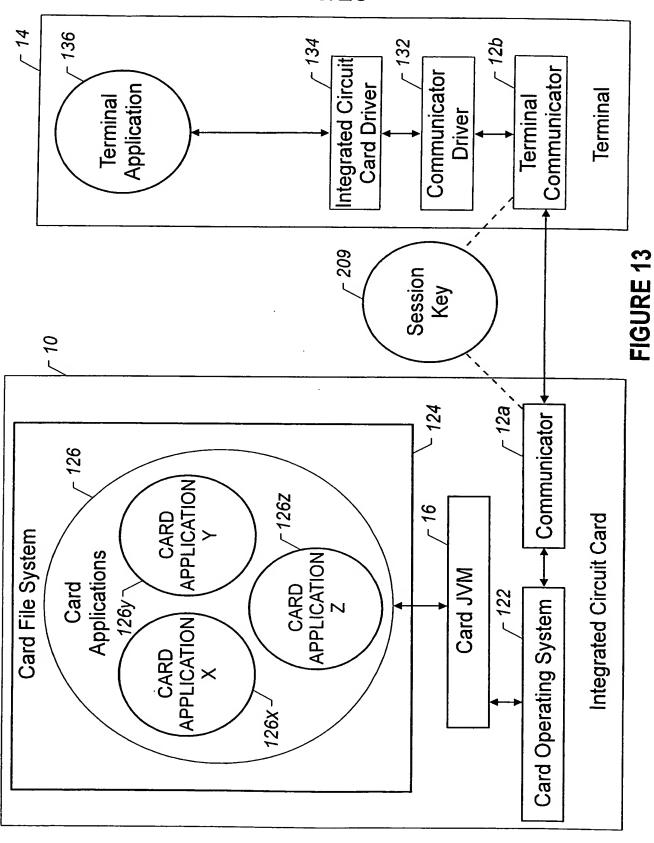Contact: Pehr B. Jansson, 512-331-3748

Word-Based Operand Stack

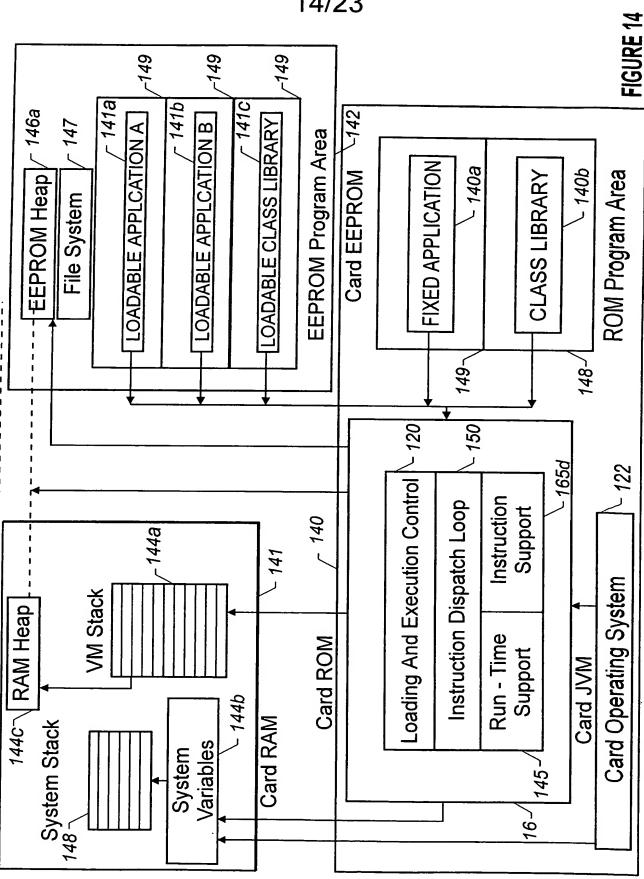Byte-Based Operand Stack

FIGURE 11

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Title: Using a High Level Programming Language with a ●ntroller
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Integrated Circuit Card — 124

Card Applications — 126

CARD APPLICATION Y — 126y

CARD APPLICATION X — 126x

CARD APPLICATION Z — 126z

Card File System

Loading And Execution Control — 120

Card Operating System — 122

10

Card Loader — 28

FIGURE 12

FIGURE 13

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a ...ontroller
Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748

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FIGURE 14

Applicant: Wilkinson et al.
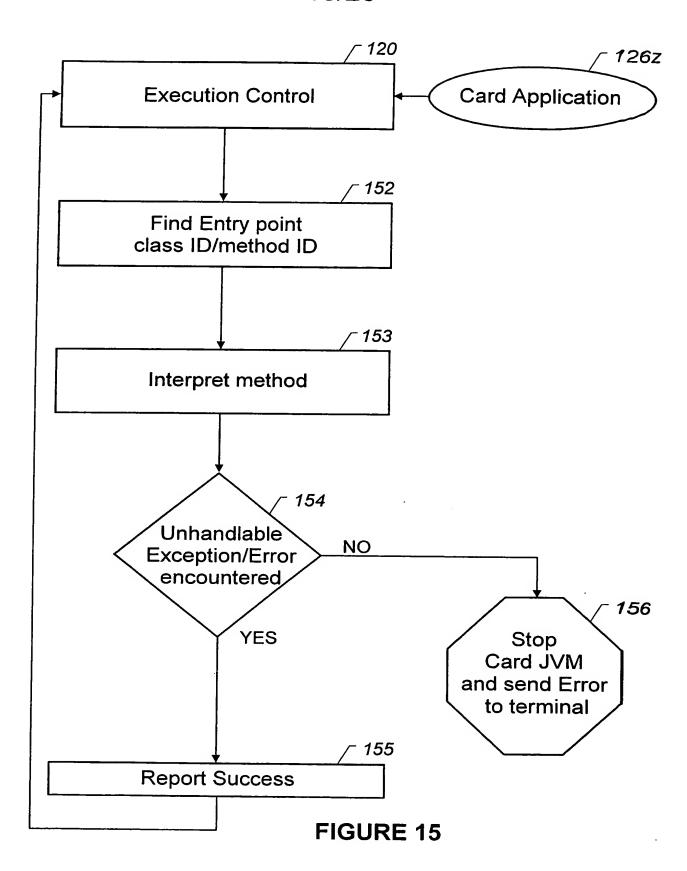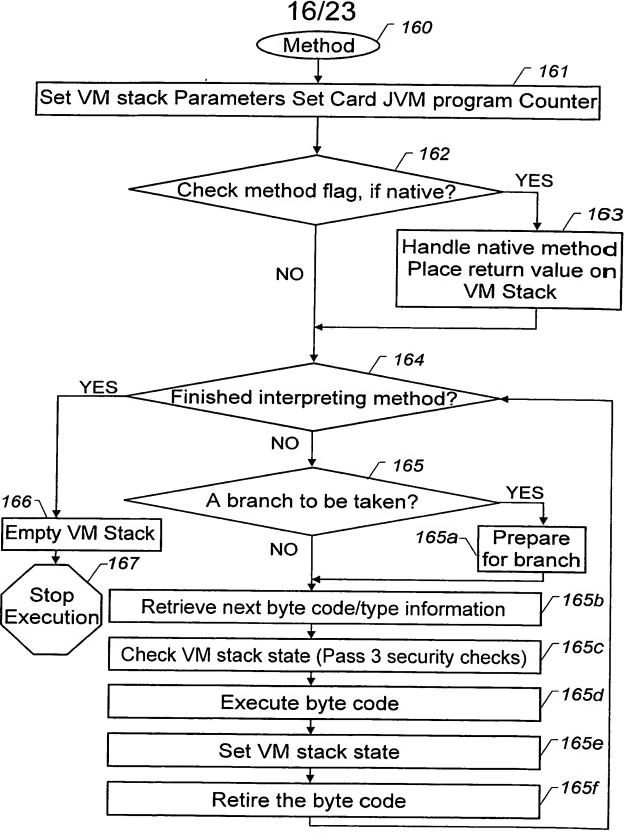Title: Using a High Level Programming Language with a Controller
Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748

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```
                                    ┌─ 120                          ┌─ 126z
┌──────────────────────────────────┐         ╭─────────────────────────╮
│        Execution Control         │◄────────│     Card Application     │
└──────────────────────────────────┘         ╰─────────────────────────╯
                  │
                  ▼                ┌─ 152
┌──────────────────────────────────┐
│          Find Entry point        │
│        class ID/method ID        │
└──────────────────────────────────┘
                  │
                  ▼                ┌─ 153
┌──────────────────────────────────┐
│          Interpret method        │
└──────────────────────────────────┘
                  │
                  ▼
              ╱ ─ 154 ╲
```

Unhandlable Exception/Error encountered — NO → **Stop Card JVM and send Error to terminal** (156)
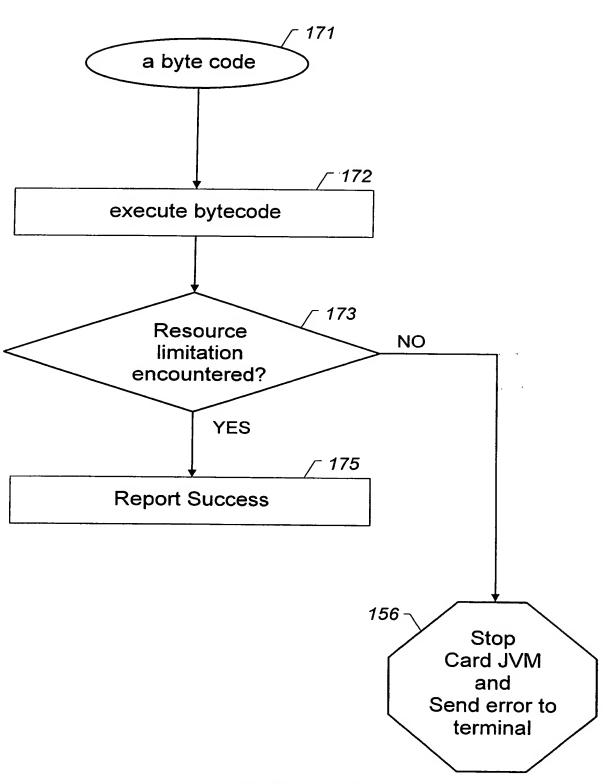
YES → **Report Success** (155)

FIGURE 15

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a   Controller
Serial No. 10/037,390
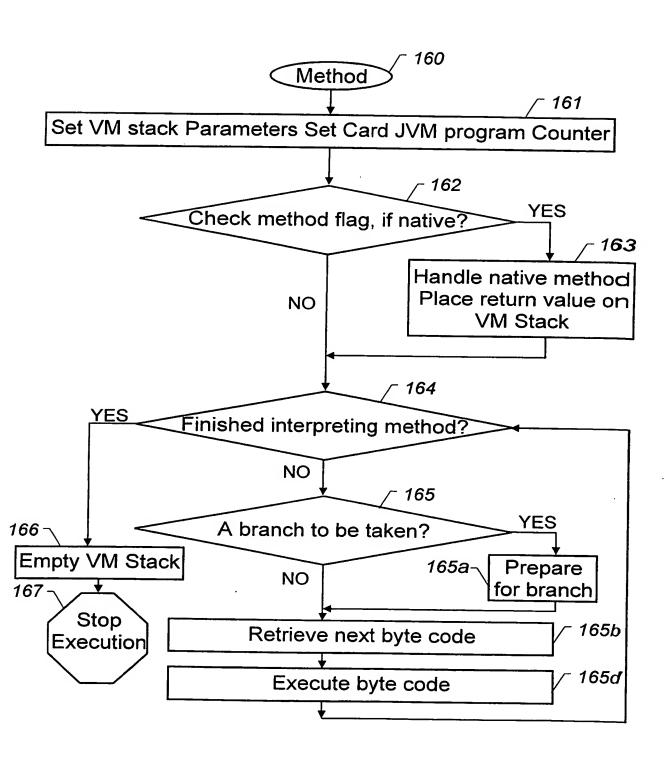Contact: Pehr B. Jansson, 512-331-3748

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Method — *160*

Set VM stack Parameters Set Card JVM program Counter — *161*

Check method flag, if native? — *162*

YES

Handle native method
Place return value on
VM Stack — *163*

NO

Finished interpreting method? — *164*

YES

NO

A branch to be taken? — *165*

YES

Empty VM Stack — *166*

NO

165a — Prepare for branch

Stop Execution — *167*

Retrieve next byte code/type information — *165b*

Check VM stack state (Pass 3 security checks) — *165c*

Execute byte code — *165d*

Set VM stack state — *165e*

Retire the byte code — *165f*

FIGURE 16

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a ⬤ ontroller
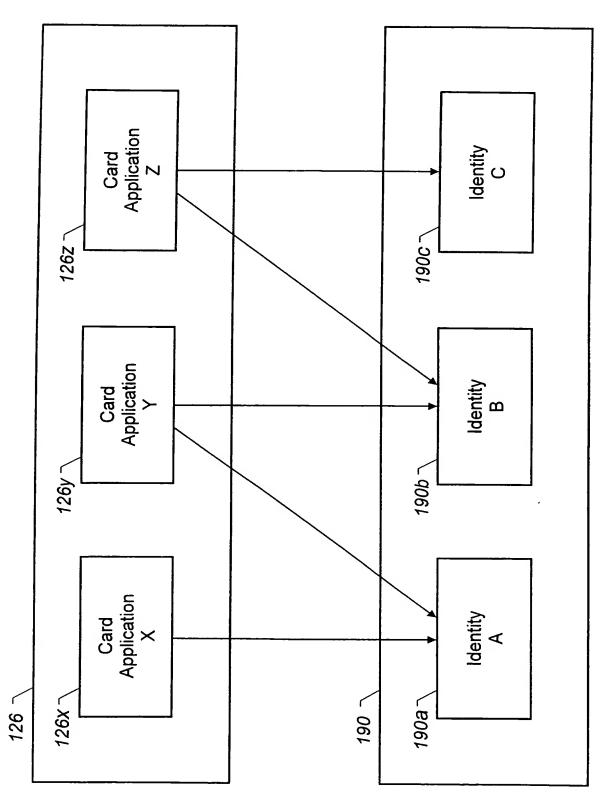Serial No. 10/037,390
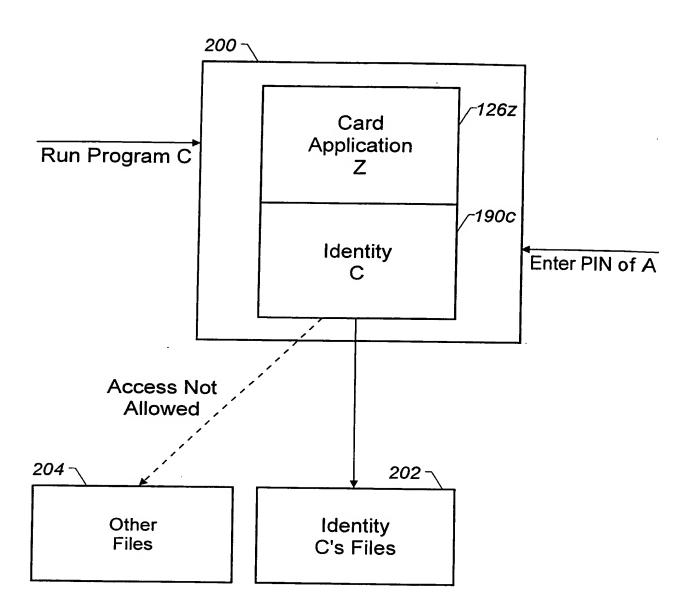Contact: Pehr B. Jansson, 512-331-3748

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```
                    ┌ 171
        ┌─────────────────────┐
       (    a byte code        )
        └─────────────────────┘
                  │
                  ▼
                    ┌ 172
        ┌─────────────────────┐
        │   execute bytecode   │
        └─────────────────────┘
```

FIGURE 17

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a ⬤ Controller
Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748
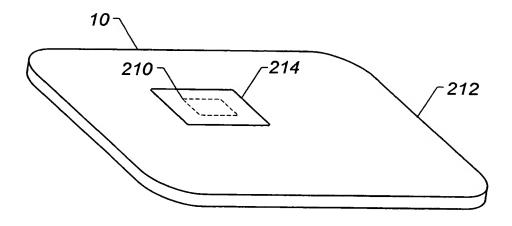
18/23

FIGURE 18

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a ⬤ ontroller
Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748
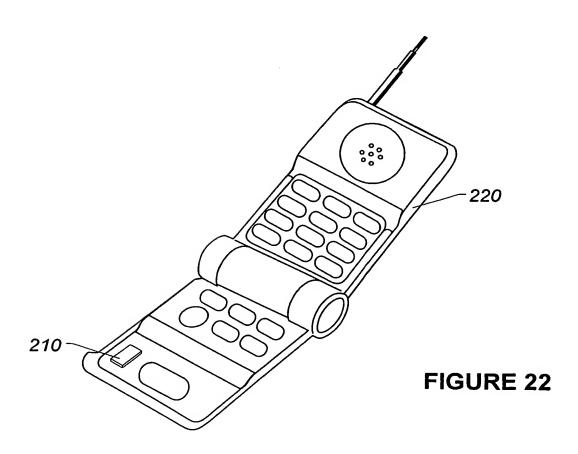
19/23

FIGURE 19

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a ⬤ontroller
Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748

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200

| Card Application Z | 126z |
| Identity C | 190c |

Run Program C →

← Enter PIN of A

Access Not Allowed

204

Other Files

202

Identity C's Files

FIGURE 20

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a ▮ontroller
Serial No. 10/037,390
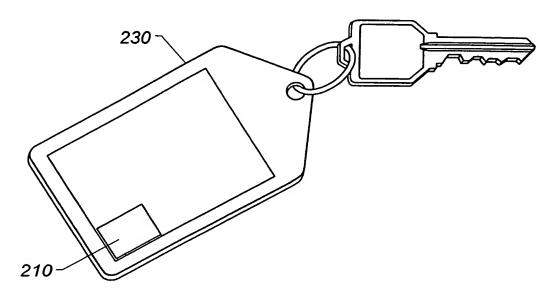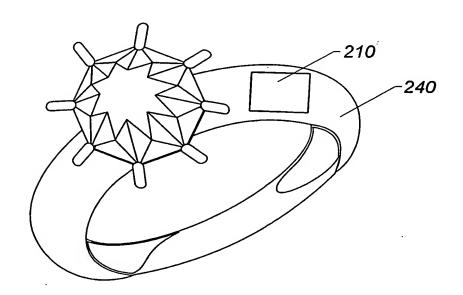Contact: Pehr B. Jansson, 512-331-3748

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FIGURE 21

FIGURE 22

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a [blacked out] Controller
Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748

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230

210

FIGURE 23

210

240

FIGURE 24

Applicant: Wilkinson et al.
Title: Using a High Level Programming Language with a ⬤ Controller
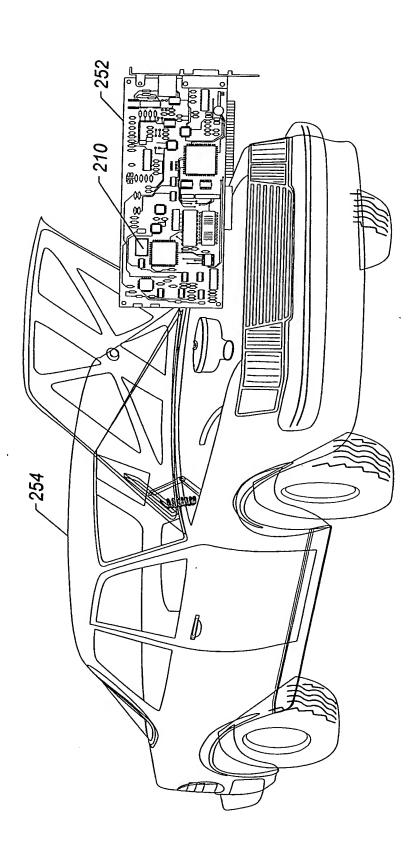Serial No. 10/037,390
Contact: Pehr B. Jansson, 512-331-3748

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252

210

254

FIGURE 25